TITLE: HOME AGENT REDUNDANCY IN A CELLULAR SYSTEM

<u>SPECIFICATION</u>

<small>BACKGROUND</small>

1. Technical Field

The present invention relates generally to cellular wireless communication systems; and more particularly to the servicing of packet data communications within such cellular wireless communication networks.

2. Related Art

The structure and operation of cellular wireless communication systems (cellular systems) is generally known. In such cellular systems, mobile subscriber units communicate wirelessly with base stations. The base stations couple the serviced communications via various cellular system elements to the public switched telephone network (PSTN), the Internet, and/or to other communication networks.

While cellular wireless communication systems were originally constructed to solely service voice communications, they have since been modified to support data communications as well. Cellular systems now support Internet Protocol (IP) based packetized communications, among others. These IP communications are relayed between the subscriber unit and the Internet (or another IP network) via the cellular system.

In relaying IP based communications between the subscriber unit and the Internet, the cellular system must recognize that the service communication is an IP

1

communication and must process the communication accordingly. Thus, cellular systems that service IP communications typically support standardized operations, e.g., IETF (RFC 2002), 3GPP2 (TIA/EIA/ISD-835), and other standards. According to these standards, various agents are defined that, when deployed, oversee and control the transfer of packetized IP communications (IP packets) between the subscriber units and the Internet. Examples of these agents include home agents and foreign agents. In these standards, each subscriber unit is associated with a particular home agent. The home agent oversees and manages the IP communications serviced by the cellular wireless network.

Because each subscriber unit has a corresponding home agent, during initial registration operations, the subscriber unit must register with its assigned home agent. In order to facilitate these registration operations, each subscriber unit is hard-coded with the IP address of its assigned home agent during its initial programming. Thus, when the subscriber unit initiates registration, it queries its assigned home agent using the hard-coded IP address and requests registration.

However, because the IP address of its assigned home agent is hard-coded in its memory, if the assigned home agent is not operational (not an uncommon event) when the subscriber unit attempts registration, a failure in registration results. This failure in registration will preclude the subscriber unit from receiving IP communication

2

service from its cellular system provider. The corresponding subscriber will immediately recognize this failure and will take steps to remedy this failure. An immediate remedy for this problem will be to contact the service provider.

5   However, the serviced provider cannot remedy this problem without receiving and reprogramming the phone.

Thus, there is a need in the art for a system and corresponding method of operation to overcome these operational problems.

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SUMMARY OF THE INVENTION

In order to overcome the above-cited shortcomings, among other shortcomings of the prior art, operation according to the present invention programs the subscriber unit with a plurality of IP addresses, each corresponding to a home agent

15   of the service provider. These programmed IP addresses include the IP addresses of a primary home agent and a secondary home agent. Upon an initial registration attempt, the subscriber unit attempts to register with its primary home agent. Should this operation fail, the subscriber unit

20   attempts registration with its assigned secondary home agents.

In one embodiment of the present invention, a primary home agent IP address and a single secondary home agent IP address are stored within the memory of the subscriber unit

25   when it is initially programming by the service provider. This methodology may be extended to include more than a

3

single secondary home agent IP address so that the identity of multiple secondary home agents are programmed.

According to another operation of the present invention, should the primary home agent fail to service the registration request, the subscriber unit will rank order a plurality of secondary home agents for which it has been programmed. Such ranking may be based upon the generation of a random number and with the random number used to rank the plurality of secondary home agents. In another operation according to the present invention, a date or time of day is employed in rank ordering the plurality of secondary home agents. Each of these methodologies will therefore distribute load among the plurality of secondary home agents. Thus, when a primary home agent to which a plurality of the subscriber units have been assigned fails, a single secondary home agent will not be overloaded by each of the subscriber units that have been previously assigned to a failed primary home agent.

According to another operation of the present invention, the service provider's network may from time to time initiate parameter updating with the subscriber unit to set or reset the primary and/or secondary home agents for the subscriber unit. While such operation may not reprogram the primary home agent for already registered subscriber units, such operation is desirable to reprogram the secondary home agents for the subscriber unit. Thus, when additional home agents are added to the service provider's IP network in order to

4

service additional load, such reprogramming is employed to more evenly distribute the subscriber unit load among the plurality of agents.

These, and other features and advantages of the present invention will become apparent from the following detailed description of the invention made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

FIG. 1 is a system diagram illustrating a cellular system that services data communications according to the present invention;

FIG. 2 is a logic diagram illustrating operation according to the present invention;

FIGs. 3A and 3B are logic diagrams illustrating operations for rank ordering a plurality of secondary home agents according to the present invention;

FIG. 4 is a logic diagram illustrating methodologies for programming or reprogramming home agent identities in a subscriber unit according to the present invention;

FIG. 5 is a message flow diagram illustrating operation according to the present invention; and

FIG. 6 is a block diagram illustrating the components of a subscriber unit that operates according to the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

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FIG. 1 is a system diagram illustrating a cellular system that services data communications according to the present invention. Some of the components of the cellular system of FIG. 1 service only data communications while other

10 components service both voice and data communications. Components that service both voice and data communications include base stations 102, 104, 106, and 108. Further, Base Station Controllers (BSCs) 120 and 122 also service both voice and data communications. Each of the base stations 102

15 through 108 couples to a servicing base station controller (BSC). In such case, base stations 102 and 104 couple to BSC 120. Further, base stations 106 and 108 couple to BSC 122.

Base stations 102 through 108 service subscriber units 110 through 118. As shown, the subscriber units 110-118

20 include handheld telephones 110 and 118, which service both voice and data communications. Further, handheld data unit 116 and laptop computers 112 and 114 access the cellular wireless communication system to service their data communication requirements. Moreover, these devices 112, 114

25 and 116 may also service voice communication service in a packetized manner, e.g., Voice over Internet Protocol (VoIP).

6

According to one operation of the cellular system of FIG. 1, the base stations 102-108 may route voice communications differently than they route data communications. Such is the case because, in current generation cellular systems, data communications are packetized communications while voice communications are circuit switched communications. However, in next generation cellular systems, both voice communications and data communications will be packetized communications. In such case, both the voice communications and data communications are serviced using the same or similar network connections. However, even in such next generation the cellular wireless communication systems, voice communications may require interworking between existing telephone networks, e.g., PSTN, in the cellular wireless communication systems.

Thus, in a current generation cellular system, each BSC 120 and 122 couples to a Mobile Switching Center (MSC) 150 that couples to the Public Switched Telephone Network (PSTN) 152 to service voice communications. However, in a next generation cellular system, some voice communications are routed via the service provider IP network 130 to the PSTN 152 via an Interworking Function (IWF) 154. Further, other voice communications may be routed via the Internet 132 or another packet data network to their destination.

BSCs 120 and 122 couples to the service provider's IP network 130 via packet control functions (PCFs) 126 and 128 and Packet Data Service Nodes (PSDNs) 124 and 134. The PCFs

7

may reside in various configurations with respect to BSCs 120 and 122 and the service provider's IP network 130. As is shown, PCF 126 is a stand alone device, couples to BSC 120, and couples to the service provider's IP network 130 via PDSN

5   134. However, PCF 128 resides within PDSN 124 that couples directly to both BSC 122 and the service provider's IP network 130. In the illustrated embodiment, the PCFs 126 and 128 service all packetized IP communications that the base stations 102 through 108 service.

10 The service provider IP network 130 couples directly to the Internet 132. However, in other embodiments, this connection may be via a firewall or some other intermediate device. Also coupled to the service provider's IP network 130 are home agents (HAs) 138 and 140 and a foreign agent

15 (FA) 142. Generally speaking, the FA 142 services IP communications for those subscriber units visiting the service provider's IP network 130 while the HAs 138 and 140 service IP communications for the service provider IP networks 130 home subscriber units.

20 A second service provider IP network 136 couples to the Internet 132 and includes HAs 146 and 148 and FA 144. Service provider IP network 136 may be operated by a service provider other than that which operates service provider IP network 130. However, a common service provider may operate

25 both service provider IP network 130 and service provider IP network 136 even though these service provider IP networks 130 and 136 service different geographic areas. When a

8

subscriber unit, e.g., subscriber unit 110, initially registers for data communication services, it must register with a corresponding HA. In such case, the subscriber unit 110 initially contacts a servicing base station 102 and requests to be registered with its primary HA 138 (for which it was programmed). This registration request is directed to the IP address of the primary HA 138. The base station 102 via its servicing BSC 120, PCF 126, PDSN 134, and service provider network 130, forwards the registration request to the primary HA 138. If the HA 138 is operational, the HA 138 registers the subscriber unit 110 for data services. Subsequently, the cellular system will support the data services.

However, should HA 138 be nonfunctional due to catastrophic failure or other events, the HA 138 will not respond to the registration request initiated by subscriber unit 110. According to the prior art operation, upon the HA's 138 failure to service the registration request, the subscriber unit 110 would simply receive no response. This lack of response would preclude subscriber unit 110 from receiving data service.

According to the present invention, the subscriber unit 110 is programmed to include both a primary HA assignment and at least one secondary HA assignment. Thus, should the primary HA 138 fail to service the registration request, the subscriber unit 110 initiates registration with a secondary HA. In continuation of the prior example, with HA 138

9

failing to respond to the registration request from the subscriber unit 110, the subscriber unit 110 identifies HA 140 as a secondary HA for subscriber unit 110. In such case, the subscriber unit 110 then initiates registration with HA

5   140 after a failed registration operation with HA 138. If registration with HA 140 is successful, HA 140 subsequently services the subscriber unit's 110 IP communications.

The principles of the present invention may be extended so that HAs that couple to different portions of the

10 subscriber provider's IP network may also serve as secondary HAs. In this embodiment, HA 138, while serving as the primary HA for subscriber unit 110, has experienced catastrophic failure. Thus, during a registration operation, the subscriber unit 110 initially attempts registration with

15 HA 138 but HA 138 fails to respond. Then, subscriber unit 110 attempts registration with secondary HA 146 that couples to service provider IP network 136. HA 146 responds to the registration request and services subsequent data communications for the subscriber unit 110.

20 FIG. 2 is a logic diagram illustrating operation according to the present invention. Operation commences with the subscriber unit initiating registration operations for data communications (step 202). In such case, the subscriber unit sends a registration request with the programmed IP

25 address corresponding to its primary HA (step 204). If this registration operation is successful, as determined at step

206, the registration operation is completed (step 208) and operation ends.

However, if the attempted registration operation with the primary HA is unsuccessful, as determined at step 206, the subscriber unit determines a secondary HA and its corresponding IP address (step 210). The subscriber unit then sends a registration request to the secondary HA (step 212). If this registration operation with the secondary HA is successful, as determined at step 214, operation proceeds to step 208 where registration with the secondary HA is completed.

However, if attempted registration with the first selected secondary HA is not successful, the subscriber unit determines a next selected secondary HA (step 216). The subscriber unit then attempts registration with the next selected secondary HA (step 218). If such attempted registration is successful, as determined at step 220, the registration is completed (step 208) and operation ends. However, if such attempted registration with the third HA is not successful, as determined at step 220, operation may continue until the list of secondary HAs is exhausted. If all HAs are exhausted without a successful registration, operation ends unsuccessfully. However, in all contemplated deployments of the present invention at least one secondary HA will be available to service a registration request.

FIGs. 3A and 3B are logic diagrams illustrating operations for rank ordering a plurality of secondary home

11

agents according to the present invention. As was previously described, a service provider initially assigns HAs to its subscriber units in an attempt to distribute load among the HAs. However, no such mechanism exists for distributing load among secondary HAs should the primary HA fail. In order to address this deficiency, the operations of FIG. 3A and FIG. 3B provide techniques for distributing load across secondary HAs should a primary HA fail. These techniques provide great benefits by distributing load among a plurality of secondary HAs instead of simply shifting all load previously serviced by a failed primary HA to a single secondary HA.

Referring particularly to FIG. 3A, in selecting a secondary HA, the subscriber unit first determines a random number (step 302). Then, based upon the random number generated by the subscriber unit, the subscriber unit rank orders its assigned secondary HAs (step 304). Then, based upon this rank ordering of secondary HAs, the subscriber unit attempts registration with the secondary HAs (step 306).

Referring now to FIG. 3B, using another technique for rank ordering secondary HAs, the subscriber unit determines a current date (or time of day) (step 352). Then, based upon the date (or the time of day), the subscriber unit rank orders all of the secondary HAs to which it has been assigned (step 354). Next, based upon its rank ordering of the secondary HAs, the subscriber unit attempts registration with secondary HAs according to the rank ordering (step 356).

FIG. 4 is a logic diagram illustrating methodologies for programming or reprogramming home agent identities in a subscriber unit according to the present invention. Because from time to time the service provider will add HAs to its network, the static assignments that have been previously made regarding primary and secondary HAs will become outdated. Thus, the operations of FIG. 4 are employed to reassign primary and secondary HAs for particular subscriber units. Parameter updating operations are generally defined by various operating standards. In these parameter-updating operations, a service center that is operated by the service provider initiates parameter update sessions with subscriber units. In these parameter update sessions, the service center provides programming information to the subscriber units. Such programming information includes subscriber unit settings, such as primary and secondary HA information, and may include new software instructions.

Referring particularly to FIG. 4, in a first operation, cellular network initiates parameter update operations with the subscriber unit (step 402). Then, the cellular network optionally downloads a primary HA IP address to the subscriber unit (step 404). Next, the cellular network downloads at least one secondary HA IP address to the subscriber unit (step 406). Further, the cellular network downloads other parameters to the subscriber unit during this particular parameter updating operation (step 408).

FIG. 5 is a message flow diagram illustrating operation according to the present invention. As is shown in FIG. 5, a subscriber unit initiates registration with its assigned primary HA and, upon failure in this registration operation,

5   the subscriber unit initiates registration with a secondary HA.

In such operation, at step 502, the subscriber unit attempts registration with its primary HA.   In this operation, the subscriber unit sends a registration request

10   with to its primary HA, HA-1, via a servicing FA.   At step 504, the FA forwards the registration request to the primary HA, HA-1.   After a period of time without a response, the subscriber unit at step 506 retransmits the registration request via the FA to the primary HA, HA-1.   The FA also

15   forwards this registration request to HA-1 at step 508. After the HA-1 again fails to respond to the registration request, the subscriber unit attempts registration for a last time at step 510.   At step 512, the FA forwards this last registration request to HA-1.

20   After three tries without a response from HA-1, the subscriber unit selects a first secondary HA, HA-2, and attempts registration with HA-2.   In such case, at step 514, the subscriber unit sends a registration request to HA-2.   At step 516, the FA forwards the registration request to HA-2.

25   At step 518, HA-2 responds to the registration request with a registration request confirmation message.   The HA-2 sends this response to FA at step 518 and the FA forwards the

14

message to the subscriber unit at step 520. The subscriber unit is then registered with HA-2 and HA-2 services the subscriber unit's data communications at step 522.

FIG. 6 is a block diagram illustrating the components of subscriber unit that operates according to the present invention. The mobile station 602 supports standardized operations that are compatible with the teachings of the present invention, with modification. The mobile station 602 includes an RF unit 604, a processor 606, and a memory 608. The RF unit 604 couples to an antenna 605 that may be located internal or external to the case of the mobile station 602. The processor 606 may be an Application Specific Integrated Circuit (ASIC) or another type of processor that is capable of operating the mobile station 602 according to the present invention. The memory 608 includes both static and dynamic components, e.g., DRAM, SRAM, ROM, EEPROM, etc. In some embodiments, the memory 608 may be partially or fully contained upon an ASIC that also includes the processor 606. A user interface 610 includes a display, a keyboard, a speaker, a microphone, and a data interface, and may include other user interface components. The RF unit 604, the processor 606, the memory 608, and the user interface 610 couple via one or more communication buses/links. A battery 612 also couples to and powers the RF unit 604, the processor 606, the memory 608, and the user interface 610.

The IP address of a primary HA, HA-1, and a plurality of secondary HAs, HA-2, HA-3, etc. 616 are stored in memory 608.

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During operation according to the present invention, these IP addresses are employed for registration according to the operations described with reference to FIGs. 1-5. These HA IP addresses may be programmed into the mobile station 602 at

5   the time of manufacture, during a service provisioning operation, such as an over-the-air service provisioning operation, or during a parameter updating operation. The structure of the mobile station 602 illustrated is only an example of one mobile station structure. Many other varied

10   mobile station structures could be operated according to the teachings of the present invention.

The invention disclosed herein is susceptible to various modifications and alternative forms. Specific embodiments therefore have been shown by way of example in the drawings

15   and detailed description. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the invention is to cover all modifications, equivalents and alternatives falling within

20   the spirit and scope of the present invention as defined by the claims.